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SCREENING AND EVALUATION FOR MATURITY DIVERSITY IN POTATO (*Solanum tuberosum* L.) GERMPLASM ACCESSIONS

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ABSTRACT

Potato (*Solanum tuberosum* L.) is a major vegetable food crop and an effective germplasm management is essential for conserving biodiversity and supporting breeding programs. Foliage maturity assessment represents a critical component of germplasm evaluation, providing insights into growth duration and suitability for targeted improvement. The present study was conducted at the ICAR–Central Potato Research Institute, Regional Station, Patna, during 2020–21 and 2021–22, involving 140 and 99 potato accessions, respectively. Germplasm lines were planted in two rows (3 m length) with 20 cm plant spacing and 60 cm row spacing. Foliage maturity was evaluated periodically from 60 to 90 days after planting at 10 days intervals to determine the optimum maturity stage. In 2020–21, sixteen accessions (*e.g.*, CP 3656, CP 3660, CP 3661, CP 3665, CP 3673, CP 3690, CP 3724, CP 3730, CP 3734, CP 3763, CP 3774, CP 3791, CP 3838, CP 3847, CP 3850, CP 3878) exhibited early foliage maturity, while in 2021–22, eleven accessions consists of CP 3660, CP 3661, CP 3662, CP 3665, CP 3683, CP 3693, CP 3700, CP 3702, CP 3718, CP 3847 were identified as early maturing. These accessions were further evaluated for tuber development and utilized as parental lines in breeding programs aimed at developing varieties suitable for early maturity and early to timely planting. The findings highlight the significance of systematic foliage maturity assessment in identifying valuable genetic resources for potato crop improvement.

Key words : Potato germplasm, Foliage maturity, Early maturing accessions, Potato Breeding.

Introduction

The potato (*Solanum tuberosum* L.) is a globally important food crop, originally domesticated in the Andean highlands of South America. Archaeological evidence indicates that the Incas cultivated potatoes in the Peruvian–Bolivian Andes nearly 1,800 years ago, making it one of the earliest domesticated tuber crops. Spanish colonizers introduced the crop to Europe in the 16th century, from where it rapidly spread across continents and became a staple in diverse agro ecological regions (Singh, 2001). Today, potato ranks as the fourth most significant staple food worldwide after rice, wheat and maize (FAOSTAT, 2024). Botanically, potato belongs to the family *Solanaceae*, which also includes tomato, brinjal, chillies and peppers (Gibhardt, 2016). It is the largest vegetable crop in terms of area cultivated globally and plays a vital role in food and nutritional security in women and children (Yadav *et al*., 2022). Potatoes are valued for their versatility and nutritional composition, being rich in carbohydrates (primarily starch), vitamins (notably vitamin C and B6), minerals such as potassium, zinc, and iron and dietary fibre (Yadav *et al*., 2024). They provide quick energy and serve as a key source of calories in many countries, particularly in the northern plains and hilly regions of India. The adaptability of potato to diverse climates and soils underpins its global importance. In India, potato cultivation is crucial not only for domestic consumption but also for processing industries and export markets. Its short growth duration, high productivity and nutritional value make potato indispensable in addressing

challenges of food security and dietary diversification. The germplasm screening, evaluation and management is very important aspect in crop improvement. Germplasm management is a cornerstone of crop improvement programs, particularly for potato (*Solanum tuberosum* L.), which is cultivated all over India under diverse agro ecological conditions. The germplasm screening and evaluation have valuable applications as follows.

- **Biodiversity conservation :** Germplasm collections safeguard rare, wild, and traditional landraces that might otherwise be lost due to genetic erosion, climate change, or shifts in agricultural practices.
- **Breeding Resource :** Accessions with desirable traits such as early maturity, disease resistance, abiotic stress tolerance and superior nutritional quality can be used as parental lines in breeding programs.
- **Adaptation to Climate change :** Conserved germplasm provides genetic variability needed to develop cultivars adapted to changing climatic conditions, including heat, drought and irregular rainfall.
- **Food security :** By enabling the development of varieties suited to short growing seasons, marginal soils, and diverse consumer preferences, germplasm management directly contributes to global food and nutritional security.
- **Scientific Documentation :** Proper characterization and evaluation of germplasm accessions (*e.g.*, foliage maturity, tuber quality, stress tolerance) generate valuable data that guide breeders, researchers and policymakers.
- **Distribution and Utilization :** Sharing germplasm across institutions and countries promotes collaborative research and accelerates the release of improved varieties for farmers and industry

The study was conducted for systematic collection, conservation, documentation, evaluation, and distribution of genetic resources to ensure the preservation of biodiversity and provides a foundation for breeding resilient and high yielding varieties.

Materials and Methods

Soil and Climate Prerequisites for potato

Potato (*Solanum tuberosum* L.) performs optimally in cool climates, with ideal temperatures ranging between 15–20°C. Growth is most vigorous in well drained sandy loam soils enriched with organic matter. The crop is highly sensitive to waterlogging at all stages of development—from planting through tuber initiation to maturity—making proper drainage essential for successful cultivation. In India, potato is predominantly grown during the winter (*Rabi*) season, while in the southern and hilly states it is also cultivated as a *Kharif* crop.

Field Site description

The experiment was conducted at the experimental fields of ICAR–Central Potato Research Institute, Regional Station, Patna, during the cropping years 2020–21 and 2021–22. Potato germplasm accessions were planted under the approved in house project on germplasm management. planting was carried out between 10–15 November 2020 and 8–12 November 2021, in the Rabi season. The cropping season in this region typically begins in November and concludes in the last week of February, with harvesting undertaken at physiological maturity.

Experimental Layout and Methodology

The experiment was established in two sets to facilitate comparative evaluation. All potato germplasm accessions were planted in two rows, each comprising 15 tubers. The row length was maintained at 3.0 m, with a plant to plant spacing of 20 cm, ensuring uniform distribution and adequate space for tuber development. This layout provided a standardized framework for assessing growth, foliage maturity and yield attributes of the accessions. By adopting this design, the experiment ensured:

- **Replication and reliability** of observations across sets.
- **Uniform spacing** to minimize competition effects among plants.
- **Controlled plot size** for accurate recording of morphological and maturity traits.

Seed source

The seed material of important potato germplasm accessions was procured from ICAR–Central Potato Research Institute, Regional Station (RS), Modipuram, Uttar Pradesh, during the cropping year 2020–21, comprising a total of 140 accessions. In the subsequent year (2021–22), an additional 99 accessions were obtained from ICAR–CPRI, Regional Station, Jalandhar, Punjab. These accessions were normally 40g seed sized tubers, ensuring adequate planting material for systematic evaluation.

Land preparation

A well-prepared field is primary requirement for healthy and out performing potato crop. The selected field for planting is prepared by deep ploughing (20-25 cm deep) with soil turning plough. Then field is prepared

by 2-3 cross harrowing followed by 2-3 shallow ploughing followed by levelling of the field. Field preparation plays very important role in good tuberization of the potato crop. The levelling of field is done with the help of wooden/ metallic plank. Planking help in retention of the available soil moisture in the field, which plays important role at the time of sowing and help in germination of the crop (Chidda Singh, 2001).

Methodology and quantity of fertilizer application

Potato crop is considered as heavy feeder crop. It requires high doses of fertilizers *i.e.*; 180: 60:100 (N: P: K) along with these fertilizers 22-25 tonnes/ha well decomposed farmyard manure was applied for getting better soil organic matter for better tuber yield. At the time of land preparation complete FYM, Potassium & Phosphorous along with half doses of Nitrogen were applied as basal. A good potato crop yields about 35 to 40 tonnes tubers per hectare (Chhidda Singh, 2001).

Selection of seed size and preparations

Tubers with 30 to 50 g weight are most suitable for planting and conducting the experiment. In this experiment, whole tubers of above-mentioned size were planted on the ridges. The plant-to-plant distance was 20 cm and row to row distance was 60 cm. After planting of the crop, light irrigation was given in the field provided in order to get even germination of the tubers.

Method of planting

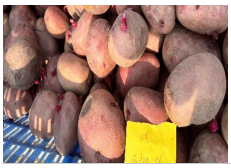
Potato crop is planted on ridges for better tuberization in number and size. The ridges were made after land preparation with the help of tractor driven ridge-maker. Bed cutting was done as per layout of the experiment (3m × 60cm × 2 lines). The planting of potato tubers of accessions were done with the help of *khurpi* at the depth of 7-8 cm and after that tubers were covered with soil. Light irrigation just after planting *i.e.*; irrigate up to the 2/3 of the ridge was given to get the even germination of experimental material.

Weed management

After planting of the crop, weedicide Oxyfluorfen 23.5% SC (500 ml/ha) was sprayed at pre- emergence stage. All inter culture operations like weeding, earthing up etc. were done manually as per requirement of the crop.

Interculture operations

The important interculture operation is hoeing, after hoeing remaining half dose of Nitrogen in the form of urea was applied in side of the furrows and then earthing up was done in order to get better tuberization in the crop. In potato crop 4-5 irrigations at an interval of 15 days were given, the interval may vary as per requirement.



Photos: Sprouted potato tubers



Planting of tubers on ridges



Earthing up operation

Disease and Pest control

Late blight of potato is very serious disease in this crop and the control can be done by one prophylactic spray of Mancozeb 75WP followed by 2 sprays of Cymoxanil 8% + Mancozeb 64% WP at an interval of 15 days. For control of as aphids and pest such as potato leaf cutters, cutworms etc Imidacloprid 17.8% SL was sprayed in 45 days crop.

Data recording

The important observations were recorded for plant emergence (%), foliage maturity (%) recorded at different physiological stages of the crop. The primary observations before planting of the crop were counting of tuber numbers required per plot were done (0.60m × 3m) × 2). Plant emergence (%) at 30 days after planting by counting of total number of tubers germinated per plot. Foliage senescence data was recorded from 60 days after planting to 90 days after planting at interval of 10 days.

Formulas:

$$1.\ \text{Plant emergence (\%)} = \frac{\text{No. of germinated plants per plot}}{\text{Total no. of planted tubers per plot}} \times 100$$

$$2.\ \text{Foliage senescence (\%)} = \frac{\text{No. of plants with 75\% foliage Maturity per plot}}{\text{Total no. of plants per plot}} \times 100$$

Crop duration

The potato accessions consist of early, medium and late maturity type. The early matures between 60 to 75 days, medium matures in 80-90 days and late 100-120 days after planting, depending on the variety.

Haulm cutting

The haulm cutting is very important activity in potato crop for seed production as well as to enhance its shelf life. In this the green vegetative part of the plant above soil is either pulled out or cut with the help of sickle without damaging underground tubers in the soil. The potato tubers which are exposed/ open during this process must be covered in the soil. The dehaulming of the crop was done at 90 days after planting. Then tubers were left in the

ground for ten days to enhance the maturity of skin of the tubers and after that lines can be harvested.

Seed treatment and packaging

Harvesting, seed treatment before storage and packaging was done as per standard procedure (Luthra *et al*., 2021). The harvested tubers were kept under shade for 10 days for curing, then treated with boric acid 2.5 to 3.0% solution and dried under shade. The treated seed is packed in the gunny bags to be kept as seed material for next season. The bags were labeled as treated both inside with aluminum tag and also on stitched tag. The treated material is not suitable for consumption purpose.

Results and Discussion

The germination percentage ranged from 70-100% (Tables 1, 2). The 36 accessions were found early maturing *viz.*; CP 1406, CP 1474, CP 1596, CP 1691, CP 1754, CP 1790, CP 1827, CP 1829, CP 1910, CP 1958, CP 1970, CP 4220, CP 4906, CP 4907, CP 4911, CP 4915, CP 4923, CP 4929, CP 4943, CP 4947, CP 4973, CP 4977, CP 4980, CP 4982, CP 4984, CP 4985, CP 4993, CP 4994, CP 4997, CP 4999, CP 5001, CP 5002, CP 5005, CP 5006 (Table 1) and CP 1406, CP 1474, CP 1596, CP 1691, CP 1754, CP 1790, CP 1827, CP 1829, CP 1910, CP 1958 (Table 2).



Accessions planted in the field | Dehaulming of the accessions | Harvesting of accessions

Photos : Important agronomical practices in potato crop.

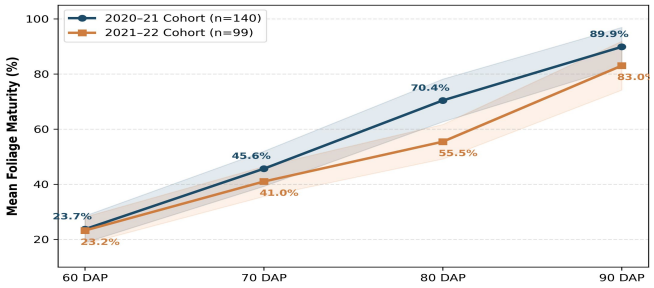


Fig. 1 : Mean foliage maturity progression (6o to 90 DAP).

The primary traits evaluated include germination percentage (%) and temporal progression of foliage maturity (measured at 60, 70, 80 and 90 Days After Planting, DAP). In addition, accessions displaying early bulking characteristics were identified for breeding and crop cycle optimization.

Germination performance Interpretation

Germination rate is a critical indicator of seed tuber viability, vigor and field establishment capability. Both evaluated cohorts showed strong establishment efficacy, with nearly all accessions surpassing the 80% germination benchmark.

Foliage Maturity Progression Dynamics (60 to 90 DAP)

Foliage maturity reflects the vegetative-to-senescence transition and serves as a vital proxy for tuber maturity and harvesting schedule. Canopy maturity was recorded at 10-day intervals from 60 DAP to 90 DAP.

The Mean Foliage Maturity Progression Trajectory (60 to 90 DAP) with ±1 SD Shaded At 60 DAP, both seasons start at a baseline of 23.7% (2020–21) and 23.2% (2021–22) maturity. Whereas, between 70 and 80 DAP,

Table 1 : Germination Vitality summary across Cropping seasons.

Crop Season	Evaluated Accessions	Mean germination (%)	Germination Range	% Accessions with 100% Germination	% Accessions >= 90% Germination
2020–21	140	95.2% ± 5.7%	70.0% – 100.0%	55.0% (n=77)	97.9% (n=137)
2021–22	99	89.2% ± 7.8%	70.0% – 100.0%	23.2% (n=23)	71.7% (n=71)
Total	239	92.7% ± 7.3%	70.0% – 100.0%	41.8% (n=100)	87.0% (n=208)

Table 2 : Statistical Progression of Foliage Maturity across evaluation Intervals.

Cropping Cohort	60 DAP Mean (%)	70 DAP Mean (%)	80 DAP Mean (%)	90 DAP Mean (%)	Maturity Gain (60 → 90 DAP)
2020–21 (n=140)	23.7% ± 4.8%	45.6% ± 6.4%	70.4% ± 7.8%	89.9% ± 7.1%	+66.1%
2021–22 (n=99)	23.2% ± 4.9%	41.0% ± 5.4%	55.5% ± 6.3%	83.0% ± 8.9%	+59.8%
Overall (n=239)	23.5% ± 4.9%	43.7% ± 6.4%	64.2% ± 10.3%	87.0% ± 8.5%	+63.5%

Table 3 : Distribution and Classification of accessions by 90-DAP Foliage maturity.

Maturity Stage at 90 DAP	2020–21 Accessions (n=140)	2021–22 Accessions (n=99)	Combined Total (n=239)	Maturity Classification
100% Maturity	34 (24.3%)	10 (10.1%)	44 (18.4%)	Early / Rapid Senescence
90% Maturity	70 (50.0%)	26 (26.3%)	96 (40.2%)	Optimal Commercial Standard
80% Maturity	36 (25.7%)	49 (49.5%)	85 (35.6%)	Medium Maturity
70% Maturity	0 (0.0%)	12 (12.1%)	12 (5.0%)	Medium-Late Maturity
60% Maturity	0 (0.0%)	2 (2.0%)	2 (0.8%)	Late / Long-duration

Table 4 : Summary of identified early Bulking Germplasm accessions.

Category/ Season	Count	Mean Germination (%)	Mean 90 DAP Maturity	Identified Accessions (CP Numbers)
2020–21 Early Bulking	34	98.2%	100.0%	CP1406, CP1474, CP1596, CP1691, CP1754, CP1790, CP1827, CP1829, CP1910, CP1958, CP1970, CP4220 etc.
2021–22 Early Bulking	10	92.0%	88.0%	CP4442, CP4446, CP4454, CP4455, CP4461, CP4465, CP4469, CP4495, CP4569, CP4583

The identified germplasm lines were utilized in the hybridization block at ICAR Central Potato Research Institute Regional Station, Patna and ICAR Central Potato Research Institute Kufri -Fagu Unit as male and female parents as the pollen load and viability.

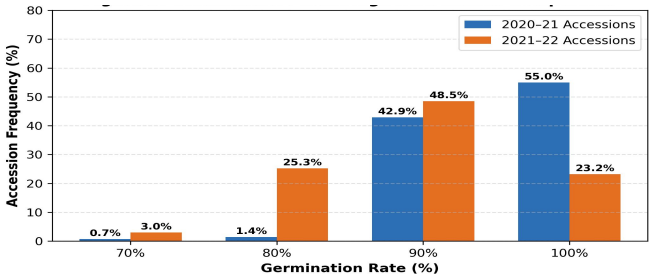


Fig. 2 : Germination percentage distribution comparison.

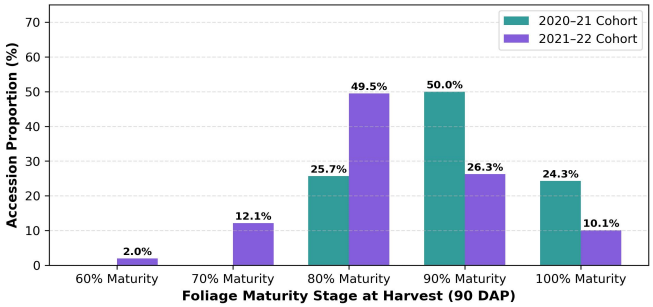


Fig. 3 : Foliage maturity profile at 90 days after planting.

the 2020–21 cohort accelerates rapidly, reaching 70.4% maturity and 2021–22 averages 55.5%. During the 2020–21 accessions reach 89.9% mean maturity compared to 83.0% in 2021–22 for 90 days after Planting.

Harvest Maturity Distribution & Classification (90 DAP)

At 90 DAP, germplasm accessions can be classified into agronomic maturity classes based on final canopy senescence:

- Full Maturity (100%): Complete canopy dry-down, ready for immediate harvest.
- High Maturity (90%): Advanced senescence, optimal for standard 90-day harvest windows.
- Medium Maturity (80%): Moderate senescence, well-suited for medium-duration regimes.
- Late Maturity (≤70%): Slower canopy breakdown, requiring extended crop duration (100–110+ DAP).

100% Maturity (Early) was observed in 24.3% lines during 2020–21 lines vs. 10.1% during 2021–22 lines. The Maturity (Standard Commercial) percentage was 90% in 50.0% lines during 2020–21 vs. 26.3% in 2021–22. The 80% Maturity (Medium Duration) represents the largest class in 2021–22 (49.5%). ≤ 70% Maturity (Long Duration) Occurred only in 2021–22 in 12.1% lines (Fig. 3).

Early Bulking Germplasm identification and traits

Early bulking accessions are vital for intensifying crop rotations, minimizing irrigation requirements, and capturing early-season market premiums. In this screening, early bulking accessions demonstrated accelerated canopy progression from 70 to 90 DAP.

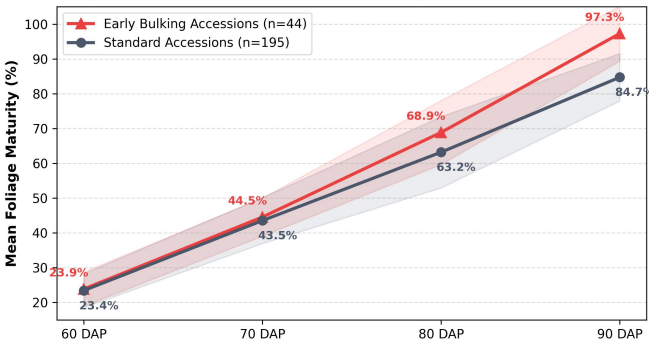


Fig. 4 : Maturity Kinetics : Early bulking vs Standard accessions.

At 60 days after planting 23.9% accessions were early bulking type and out of that 23.4% were standard accessions. The accessions showing foliage maturity 44.5% at 70 DAP.

Conclusion

Potato is a cool season crop. It performs best in cool regions with sufficient moisture and fertile soil, well prepared field for better yield. The ideal soil temperature range is between 17-19^{0}C because this temperature favours the tuber development. Potato can be grown on wide range of soils from sandy loam, silt loam and clayey soils. Well drained fields are most important and required for conducting the experiment as well for growing of the crop. The soil pH ranges from 5.0-6.5 (Chhidda Singh, 2001). The germplasm accessions were characterized for foliage maturity. foliage maturity is positively correlated with the crop duration and early maturity. The early type genotypes are generally early bulking and escape the disease late blight of potato. These accessions are important material used as parents in the breeding programme and important genetic material as resource of crop improvement.

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